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ABSTRACT

The purpose of this study was to examine the relationship between the various techniques used to estimate the time required by the human to process a visual stimuli, i.e., recognize a stimulus input into the visual perceptual system. Sixteen tests of visual processing speed were administered to 110 undergraduate students. In summary, scores tended to be only slightly correlated. The largest correlations were produced by various forms of the same technique, i.e., tachistoscope test with numbers and tachistoscope test with letters. Given the generally low intercorrelations, the factor analysis did not yield interpretable factors across various types of tests. Data produced by this study indicates that estimates of the processing speed of individuals tend to be inconsistent across various types of tasks. The notion of perceptual style as characterized by processing speed seems invalid given the use of the tests included in this study. (Author/RC)

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THE PROCESSING SPEED OF HUMANS ON VARIOUS VISUAL TASKS: AN ANALYSIS OF RELATIONSHIPS

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Kalamazoo, Michigan

U. S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE
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SUMMARY

Research on human visual perception has been heavily influened by information processing models. One of the issues which these models serve to isolate is the duration of time required by the human to process a visual stimuli, i.e., recognize a stimulus input into the visual perceptual system. A considerable number of techniques have been used to estimate processing time; yet the relationships among the estimates produced by the various techniques is not known. Therefore, the purpose of this study was to examine the relationship among the estimate. Sixteen tests were administered to 110 undergraduate students. These tests were:

1. Unobtrusive test of reading speed.
2. Tachistoscope test with symbols.
3. Unobtrusive test of looking time with recall.
4. Unobtrusive test of looking time with opinion.
5. Tachistoscope test with numbers.
6. Speed and accuracy test.
7. Oral reading of high redundant list of words.
8. Oral reading of low redundant list of words.
9. List reading with non-verbal response.
10. Tachistoscope test with letters.
11. Scan test one.
12. Scan test two.
13. Scan test three.
14. Reading speed.
15. Eye fixations on verbal materials.
16. Eye fixations on non-verbal materials.

In summary, scores on the various tests tended to be only slightly correlated. Ninety-six of the one hundred and twenty correlations were not sufficiently large in order to reject the null hypothesis at the .05 level. The largest correlations were produced by various forms of the same technique, i.e., tachistoscope test with numbers and tachistoscope test with letters. Given the generally low intercorrelations, the factor analysis did not yield interpretable factors across various types of tests. Further, the use of threshold scores to predict non-threshold scores resulted in multiple Rs of from .20 to .27.

The data produced by this study indicates that estimates of the processing speed of individuals tend to be inconsistent across various types of tasks. The notion of perceptual style as characterized by processing speed seems invalid given the use of the tests included in this study.

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INTRODUCTION AND PURPOSE

Within the last ten years, increasing use has been made of information processing models in the study of visual perception. A basic assumption of processing models of visual perception is that recognition of visual stimuli is not simultaneous with stimulation; rather, recognition is the final stage in a series of processes, each of which requires time. Upon reaching the retina, light energy is analyzed and transduced into a bioelectrical code. This signal is then transmitted through the optic nerve to the brain. At the brain the signal is redintegrated and made meaningful for the organism. Time is needed in order for a stimulus to be successfully processed since these physiological operations require time. Nerve fibers carry impulses at well below the speed of light. (Grossman, 1967.) Also, transduction, analysis, and coding - of the signal require time.

The extent of stored information and the way it is stored also will affect the time required for processing. Barlow suggests that the code which is selected for transmission of information through the visual system reflects much stored information about the environment since probabilities of sensory events are required in order to build an effective code. Barlow hypothesized that synaptic connections are genetically determined so that the organism's typical sensory environment can be represented with a minimum of activity. If the environment is changed, the time required for processing should rise until changes in synaptic connections take place. (Barlow, 1969.) The more synapses that are necessary the slower the processing since speed of conduction at synapsis is relatively slow.

The research on cognitive set demonstrates the effect of stored information upon thresholds for visual recognition. For quite some time it has been known

that changes in the stored information at the brain can affect the time required to recognize a visual stimulus (Neisser, 1954; Postman and Bruner, 1949). Thus, within the human, the nature of neurological functioning and the cognitive status of various humans with regard to a particular visual task, leads us to expect that the mean and standard deviation for the time required for visual processing will be greater than zero.

Typically, the literature on processing speed has been oriented toward the problem of estimating mean time required by humans to process certain stimuli or to the estimation of the relationship between an independent variable such as amount of information communicated by a set of stimuli and processing speed. A number of studies have been reported which furnish estimates of the visual processing speed of humans (Pierce and Karlin, 1956; Briggs and Swanson, 1970; Leckart and Bakan, 1964; Olshavsky and Gregg, 1970; Tresselt and Mayzner, 1969; Liss, 1970; Bosco, Travers, and Wilkins, 1968; and Travers and Bosco, 1967). Although all of these investigations have used the term processing speed (or rate), a variety of measurement techniques have been used. The measurement techniques differ considerably with regard to such elements as task (discrimination, recognition, search), stimuli (letters, numbers, geometric shapes), type of observed response (verbal, motor) and criteria for the selection of the estimate for each person being tested (threshold, non-threshold).

Mean processing time is affected by differences in testing conditions. Prior research, for example, indicates a relationship between the type and extent of redundancy contained by a set of stimuli and the threshold speed for visual processing (Bosco, Travers, and Wilkins, 1968). The threshold for recognition of high discrimination redundant stimuli was nearly two times faster than for low discrimination redundant stimuli.

Since little use has been made of repeated measurements with different testing procedures for the same subjects, little is known about the extent to which changes in testing conditions affect individual subjects. Increasing the discrimination redundancy of a set of stimuli, for example, may produce a similar decrease in the threshold for all subjects or it may produce differential increases and decreases in the scores for individuals which when summated results in a lower mean. In other words, the interatction between organismic variables and testing procedures is unclear.

The principal question toward which this study was oriented was: Do humans demonstrate visual information processing styles with regard to processing speed? Studies of perceptual style have focused on the problem of describing perceptual differences among individuals (rather than estimation of the mean). One of the earliest studies of perceptual style was a study by Jaensch (1930) in which two personality-perceptual types were identified. Other studies such as those by Thurstone (1944), Witkin and his colleages (Witkin, et al., 1954), and Kagan, Moss, and Sigel (1963) have attempted to identify perceptual styles as related to personality characteristics. These studies have used concepts such as field dependence-field independence, field articulation, and analytic-non-analytic modes of perception as identifications for perceptual styles. The concept "style" indicates a distinctive and typical mode of responding. Speed, as a variable, for labeling perceptual styles has received little attention.

The purpose of this study was to examine the speed with which individuals performed a variety of visual perceptual tasks. Little is known about the extent to which processing speed is a generalized human characteristic. The literature enables us to make statements about the mean speed of humans on a particular processing task, but we do not know if an individual who performed a particular

task rapidly would perform fast on a comparable task. The extent to which information about the visual processing rate of a human (as currently measured) reveals a basic and stable characteristic of the human is unknown. Although these studies enable us to conclude that person X requires more time to perceive the stimulus than does person Y, it is not possible to conclude that under different conditions person X will again require more time than person Y.

This issue will be approached by using a series of tests of visual processing speed. If various measures provide different (unrelated) assessments of the individual's processing speed, then the notion of a generalized visual processing rate is questionable. In addition to several conventional approaches to the measurement of processing speed, several less conventional tasks were included. Typically most measurement of visual perceptual speed have been threshold and reactive. In this study several non-threshold, unobtrusive measurements involving visual perceptual speed were included.

PROCEDURES

1. Subjects

College students drawn from a multi-section junior level class were the subjects for this study. Subjects were paid five dollars for participation. Each S was tested with the following sixteen tests. (Appendix A "Testing Manual" provides a more detailed description of the testing procedures.)

2. Tests

Test 1. Unobtrusive Test of Reading Speed.

S was instructed to read a brief (142 word) description of the study while the tester made final preparations for testing. The last sentence of the written statement directed the S to write his name on an envelope for payment purposes. The duration of time from the moment S made eye contact with the statement to the moment S wrote his name was recorded unobtrusively.

Test 2. Unobtrusive Test With Recall.

S was told that he would be shown a picture (a composite photograph of "bubble-gum cards") and asked questions about it. S was permitted to look at the picture for as long as he wished. The amount of looking time was recorded unobtrusively.

Test 3. Unobtrusive Test With Opinion.

S was shown two pictures and told to look at them "as long as you want" and then to select which one he preferred. Tester recorded the amount of time unobtrusively.

Test 4. Reading Speed.

S was instructed to read a passage with a high-school reading difficulty level and was informed that the length of time required

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to read the passage would be timed. S was informed that he would be questioned about the passage.

Test 5. Tachistoscope Test With Symbols.

Using a Gerbrands two stage tachistoscope, one of four geometric shapes (square, circle, triangle, star), printed in white on a black card were presented, followed by a masking stimulus which consisted of a random pattern of lines. The test stimuli were presented at 5 msec., and the masking stimulus was presented at 20 msec. The first set of four test stimuli were followed by an interstimulus interval of 90 msec. followed by the noise stimulus. Subsequent groups of four stimuli were followed by inter-exposure dark fields of 80, 70, 60, 50, 40, 30, 20, 10, and 0 msec. The visual angle of the stimuli was less than one degree and the luminescence of the stimuli was three foot lamberts.

Test 6. Tachistoscope Test With Numbers.

This test used procedures similar to Test 5, however the stimuli were four, two-digit numbers (26, 37, 48, 15) and the schedule of presentations was in 10 blocks of eight presentations with inter-stimulus intervals ranging as follows: 60, 54, 48, 42, 36, 30, 24, 10, 12, 06. The angle and luminescence were the same as in Test 5.

Test 7. Tachistoscope Test With Letters.

This test used the same general procedures as Test 5, but test stimuli consisted of letters (X, K, V, W, Z). Stimuli were presented in blocks of 10 with inter-stimulus intervals of 60, 54, 48, 42, 36, 30, 24, 10, 12, 06. The angle and luminescence were the same as in Test 5.

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Test 8. Scan Test One.

This test used a procedure developed by Neisser (Neisser, 1963), and consisted of columns of letters (with five letters in each line) which were randomly arranged. The subject was instructed to scan the columns until he located the target.

Test 9. Scan Test Two.

This test used the same procedure as Test 8 with a different list of letters.

Test 10. Scan Test Three.

This test used the same general procedure as Test 8, however the S was instructed to find a row of letters which did not contain a particular letter.

Test 11. Oral Reading of List of Highly Redundant Words.

This test used procedures developed by Pierce and Karlin (1957). Lists of words were constructed. The Ss were instructed to read the lists aloud as rapidly as possible. (Pierce and Karlin found no difference in processing rate with words read aloud or words read silently.) This form of the test used a highly redundant word list.

Test 12. Oral Reading of List of Low Redundant Words.

The procedure for this test was the same as the preceding test except a low redundant word list was used.

Test 13. List Reading With Non-Verbal Response.

For this test the subject was asked to read silently a list of words and to push a counter each time a target word (a name of a color) was read.

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Test 14. Speed and Accuracy Test.

This test was developed by Western Psychological Services and consisted of a series of two sets of stimuli. The subject was instructed to compare the two sets on each line and mark the correct answer (same, different).

Test 15. Duration of Fixation With Verbal Materials.

For this test the EDL Reading Eye Camera was used which recorded the reflection of a bead of light from the cornea of the eye onto the motion picture film. Using the processed film, the duration of fixations were measured. For this test a passage of verbal material was used.

Test 16. Duration of Fixation With Non-Verbal Materials.

For this test the Eye Camera was used, but the stimulus consisted of a picture.

3. Testing Sequence

The sixteen tests were administed in the following order:

1. Unobtrusive test of reading speed.
2. Tachistoscope test with symbols.
3. Unobtrusive test of looking time with recall.
4. Unobtrusive test of looking time with opinion.
5. Tachistoscope test with numbers.
6. Speed and accuracy test.
7. Oral reading of high redundant list of words.
8. Oral reading of low redundant list of words.
9. List reading with non-verbal response.

10. Tachistoscope test with letters.
11. Scan test one.
12. Scan test two.
13. Scan test three.
14. Reading speed.
15. Eye fixations on verbal materials.
16. Eye fixations on non-verbal materials.

4. Testing Environment

All testing was conducted in a laboratory which was set-up for the study.

FINDINGS

Of the one hundred and ten Ss who were tested, 49 (44.5%) were males and 61 (55.5%) were females. The mean age for the Ss was 19.8 years.

Table One (on page 10) contains means and standard deviations for the sixteen tests. The design of the study was established in a way which would enable comparisons among Ss rather than among test means. Thus, the same sequence of tests was used for all Ss. Such a design produces practice effect contamination in an analysis of differences between means. In other words, it is impossible to determine to what extent the mean for the third tachistoscopic test was affected by the specific stimuli which were used, as opposed to the amount of practice which was provided by the first two tachistoscope tests. In the case of the tachistoscope tests, while the practice effect was not conspicuously evident in the means (Appendix B contains procedure for locating threshold), but was evident in the percentage of correct responses below the threshold. For the first test, the percentage correct below the threshold was 11%. For the

Table One

Means and Standard Deviations
for Sixteen Tests

Test No.	Name	Mean	Standard Deviation
1	Unobtrusive test of reading speed	31.4 sec.	10.3 sec.
2	Looking time with recall	62.1 sec.	35.1 sec.
3	Looking time without recall	12.3 sec.	9.5 sec.
4	Reading test	27.3 sec.	7.4 sec.
5	Tachistoscope test-symbols	32.8 msec.	14.2 msec.
6	Tachistoscope test-numbers	28.6 msec.	10.8 msec.
7	Tachistoscope test-letters	29.8 msec.	12.1 msec.
8	Scan test A	17.8 sec.	12.7 sec.
9	Scan test B	15.9 sec.	4.5 sec.
10	Scan test C	24.6 sec.	13.3 sec.
11	Oral reading test of high redundant words	24.6 sec.	4.0 sec.
12	Oral reading test of low redundant words	26.3 sec.	8.0 sec.
13	Counter test	23.2 sec.	4.1 sec.
14	Speed and accuracy test (percent correct)	74.5 percent	13.3 percent
15	Fixation duration for verbal material	.2 sec.	.02 sec.
16	Fixation duration for non-verbal material	.3 sec.	.03 sec.

second test, the percentage was 18%, and for the third it was 20%. With this caution in mind, relative to comparisons among means, there are several observations to be made about the information in Table One.

Previous research (Bosco, 1970; Bosco, Travers, and Wilkins 1968; and Travers and Bosco, 1967) has involved the testing of other groups with some of the same stimuli and test conditions used in this study. In the 1970 study, middle to upper SES first, third and sixth grade children were compared with low SES children in the same grades. In that study it was found that the threshold means for the middle SES group were fairly constant across grade levels (1st grade 33.5 msec., 3rd grade 28.9 msec., 6th grade 25.9 msec.), but in the low SES groups considerable differences were observed (1st grade 70.3 msec., 3rd grade 46.0 msec., and 6th grade 34.8 msec.). The means for college students on the tachistoscope test with symbols (32.8 msec.) is only somewhat smaller (faster) than the mean for the middle SES first graders, and falls in between the means for the middle and low SES group sixth graders.

A prior study with college students involving the same stimuli as were used in Test 6 resulted in a mean of 25.8 msec. (Bosco, Travers, and Wilkins, 1968). When college students in a previous study were tested with the stimuli used in Test 7 a mean threshold of 29.5 msec. was obtained (Travers and Bosco, 1967). The tachistoscope test means from the present study are quite consistent with the prior findings.

The two scan tests wherein the S was instructed to find a set which contained a target stimuli resulted in lower means than the test which S was instructed to find a set which did not contain a particular stimuli. This finding is consistent with information reported by Neisser (1963).

With regard to the unobtrusive tests, Table One shows that instructing Ss to look at a picture when they know they will be asked questions about it produced longer looking times than when S was asked to make a judgment on the picture. Whereas only one S looked at the two art prints for a minute or longer, forty-seven of the Ss looked at the picture when questions were to be asked. It is interesting to note, however, that the mean rate of words per second for the unobtrusive test was 4.5 words per second and for the obtrusive test the rate was 4.2 words per second. The motivation to read faster, which would be expected in the timed situation, maybe was offset by an awareness that questions would be asked.

Table Two (on page 13) presents the correlation matrix for the sixteen tests. Inspection of this table shows that relatively few correlations exceed ± .2. Of particular interest are the correlations for various forms of the same test. Both the oral reading of word lists tests and the tachistoscope tests achieved relatively high correlations ($r > .4$). The scan tests, however, produced lower correlations ($r < \pm .1$). The test which produced the highest correlations with other tests was the first oral reading of word list test.

Of the one hundred and twenty correlations presented in Table Two, twenty-four are not sufficiently high to permit us to reject the null hypothesis at the .05 level (with 100 degrees of freedom, .20 was required for significance at the .05 level). Thus, in 20% of the correlations, we conclude that no relationship exists. Even in the case of the correlations among the various tachistoscope tests which were relatively high, approximately only 18% of the variance is shared.

The second step in the analysis consisted of factor analyses of the sixteen tests. The structure of the tests was examined with four factor analyses: principal components with varimax rotation, principal components with rotation,

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Table Two

Correlation Matrix for the 16 Tests Included for Study

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	----	.11	.19	.37	.11	-.18	.11	-.11	.03	.23	.06	.08	.13	-.24	-.05	.20
2	.11	----	.33	.13	-.08	.04	.06	.08	.05	-.00	.06	.10	.10	-.12	-.08	-.04
3	.19	.33	----	.20	-.08	-.08	.02	-.08	.08	.20	.10	.03	.07	-.09	-.04	-.10
4	.37	.13	.20	----	.19	.18	.14	.07	.30	-.08	.20	.18	.16	-.10	-.16	-.01
5	.11	-.08	-.08	.19	----	.44	.43	.07	.13	-.07	.13	.04	.05	.00	.03	.11
6	-.18	.04	-.08	.18	.44	----	.41	-.03	.16	-.06	.35	.14	.29	-.26	.05	.22
7	.11	.06	.02	.14	.43	.41	----	.16	.09	-.02	.22	.09	.15	-.19	.03	.01
8	-.11	.08	-.08	.07	.07	-.03	.16	----	.10	-.06	.01	.04	.18	-.06	-.01	-.13
9	.03	.05	.08	.30	.13	.16	.09	.10	----	-.04	.29	.14	.26	-.13	-.01	-.00
10	.23	-.00	.20	-.08	-.07	-.06	-.02	-.06	-.04	----	.03	.02	.03	-.08	-.09	-.13
11	.06	.06	.10	.20	.13	.35	.22	.01	.29	.03	----	.49	.51	-.27	-.15	-.03
12	.08	.10	.03	.18	.04	.14	.09	.04	.14	.02	.49	----	.17	-.17	-.14	-.25
13	.13	.10	.07	.16	.05	.29	.15	.18	.26	.03	.51	.17	----	-.50	-.03	.17
14	-.24	-.12	-.09	-.10	.00	-.26	-.19	-.06	-.13	-.08	-.27	-.17	-.50	----	.09	-.10
15	-.05	-.08	-.04	-.06	.03	.05	.03	-.01	-.01	-.09	-.15	-.14	-.03	.09	----	.32
16	.20	-.04	-.10	-.01	.11	.22	.01	-.13	-.00	-.13	-.03	-.25	.17	-.10	.32	----

image factor analysis with varimax rotation, and image factor analyses with oblimin rotation. For the principal componenets analyses the procedure described by Kaiser (1965) referred to as "Little Jiffy", was used to specify the number of factors to be rotated. For the image factor analyses, Kaiser's Little Jiffy was modified as follows. Communalities were summed and divided by the number of tests. This value served as the cut-off point for determining the number of factors to be rotated. Tables Three through Ten, which are found on pages 15 to 22, contain the unrotated and rotated loadings for each of the four factor analyses.

Table Eleven, on page 23, summarized the eight preceeding tables and shows the tests which load > .5 on the rotated factors for each of the four analyses. Table Eleven, along with the other factor analyses tables, show that the three tachistoscope tests load heavily on one factor in each analysis. In the two principal component analyses, all of the other loadings were below .5. In the image factor analyses, the oral reading of the high redundant words loaded heavily on this factor, and in the orthogonal rotation of the image factor analyses the counter test loaded -.510. The second factor which appeared in each of the four analyses consisted of the two duration of fixation meausres and the speed and accuracy test. The oral reading of word lists along with the counter test and one of the scan tests formed a cluster on the two principal components analyses.

The factor analyses confirms what began to be apparent from the correlation matrix, i.e., that the clustering of tests tended to be confined to alternate forms of the same general type. The inclusion of multiple forms of the same tests with other types of tests in the factor analysis tends to be inadvisable. Yet, the intercorrelations indicate that a factor analysis with the multiple forms removed would be non-productive.

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Table Three

Unrotated Factor Matrix for Principal Components Analysis with Varimax Rotation

Test	Factor 1	2	3	4	5
1	.543	.302	-.039	-.483	.024
2	.317	.476	-.163	.178	.473
3	.262	.691	-.092	-.099	.306
4	.645	.153	-.102	-.005	.184
5	.506	-.496	-.156	-.292	.235
6	.621	-.335	-.299	-.280	-.041
7	.535	-.335	-.347	-.172	.261
8	.235	-.160	-.144	.596	.324
9	.598	.021	-.051	.290	-.075
10	.227	.446	.087	-.322	-.287
11	.794	.044	-.114	.181	-.345
12	.534	.134	-.225	.283	-.411
13	.752	.052	-.097	.190	-.227
14	.343	-.076	.729	.118	.159
15	.681	-.082	.547	.040	.054
16	.691	-.116	.461	-.141	.018

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Table Four

Factor Matrix for Principal Components Analysis with Varimax Rotation

Test	Factor 1	2	3	4	5
1	.365	.372	.165	.177	-.539
2	.029	.758	.031	.123	.134
3	-.063	.767	.005	.065	-.249
4	.347	.427	.217	.362	-.039
5	.791	-.044	.183	.051	.063
6	.746	-.060	.050	.334	-.105
7	.744	.133	.020	.174	.117
8	.081	.207	.075	.252	.666
9	.161	.165	.222	.577	.126
10	-.089	.176	.067	.200	-.601
11	.246	.078	.205	.823	-.101
12	.039	.050	-.028	.772	-.052
13	.244	.142	.220	.732	-.043
14	-.070	.020	.827	.007	.071
15	.184	.079	.804	.294	-.045
16	.313	.043	.725	.258	-.176

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Table Five

Unrotated Factor Matrix for Principal Components Factor Analysis with Oblimin Rotation

Test	Factor 1	2	3	4	5
1	.543	.302	-.039	-.483	.024
2	.317	.476	-.163	.178	.473
3	.262	.691	-.092	-.099	.306
4	.645	.153	-.102	-.005	.184
5	.506	-.496	-.156	-.292	.235
6	.621	-.361	-.299	-.280	-.041
7	.535	-.335	-.347	-.172	.261
8	.235	-.160	-.144	.596	.324
9	.598	.021	-.051	.290	-.075
10	.227	.446	.087	-.322	-.287
11	.794	.044	-.114	.181	-.345
12	.534	.134	-.225	.283	-.411
13	.752	.052	-.097	.190	-.227
14	.343	-.076	.729	.118	.159
15	.681	-.082	.547	.040	.054
16	.691	-.116	.461	-.141	.018

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Table Six

Rotated Matrix for Principal Components
Factor Analysis with Oblimin Rotation

Test	Factor 1	2	3	4	5
1	-.079	.338	.104	-.524	.329
2	-.037	.776	-.015	.163	-.009
3	.016	.780	-.035	-.222	-.020
4	-.272	.379	.149	-.012	.289
5	.051	-.082	.122	.055	.802
6	-.262	-.124	-.029	-.098	.733
7	-.077	.097	-.058	.122	.746
8	-.234	.188	.050	.685	.050
9	-.552	.093	.170	.157	.083
10	-.187	.150	.049	-.585	-.130
11	.810	-.029	.132	-.062	.145
12	-.803	-.034	-.085	-.012	-.046
13	-.706	.048	.151	-.006	.150
14	.050	-.016	.852	.070	-.133
15	-.216	.005	.785	-.033	.096
16	-.170	-.030	.697	-.168	.240

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Table Seven

Unrotated Matrix for Image Analysis
with Varimax Rotations

Test	Factor 1	2	3
1	.469	-.016	-.116
2	.254	-.107	-.192
3	.213	-.129	-.321
4	.533	-.109	-.091
5	.427	-.003	.351
6	.558	-.109	.292
7	.457	-.117	.272
8	.188	-.055	.057
9	.522	-.067	-.032
10	.189	-.053	-.220
11	.743	-.164	-.032
12	.482	-.244	-.098
13	.717	-.096	-.054
14	.312	.436	-.079
15	.631	.393	-.038
16	.658	.330	-.015

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Table Eight

Rotated Matrix for Image Factor Analysis
with Varimax (Orthogonal) Rotation

Test	Factor 1	Factor 2	Factor 3
1	.267	.225	-.334
2	.093	.052	-.318
3	-.009	.028	-.405
4	.317	.181	-.394
5	.525	.162	.060
6	.615	.140	-.101
7	.534	.086	-.068
8	.187	.036	-.073
9	.373	.197	-.316
10	.013	.070	-.286
11	.561	.218	-.466
12	.359	.031	-.415
13	.508	.268	-.443
14	.037	.538	-.052
15	.304	.650	-.199
16	.358	.605	-.220

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Table Nine

Unrotated Factor Matrix for Image Factor Analysis with Oblimin Rotation

Test	Factor 1	Factor 2	Factor 3
1	.469	-.016	-.116
2	.254	-.107	-.192
3	.213	-.129	-.321
4	.553	-.109	-.091
5	.427	-.003	.351
6	.558	-.109	.292
7	.457	-.117	.272
8	.188	-.055	.057
9	.522	-.067	-.032
10	.189	-.053	-.220
11	.743	-.164	-.032
12	.482	-.244	-.098
13	.717	-.096	-.054
14	.312	.436	-.079
15	.631	.393	-.038
16	.658	.330	-.015

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Table Ten

Rotated Matrix for Image Factor Analysis
with Oblimin (Oblique) Rotation

Test	Factor 1	Factor 2	Factor 3
1	-.207	.158	-.284
2	-.049	.005	-.315
3	.070	-.012	-.426
4	-.320	.088	-.334
5	-.552	.089	.162
6	-.631	.034	.014
7	-.556	-.006	.029
8	-.187	-.001	-.041
9	-.330	.112	-.249
10	.036	.041	-.293
11	-.510	.087	-.373
12	-.327	-.072	-.373
13	-.447	.151	-.354
14	.051	.558	.004
15	-.200	.616	-.094
16	-.262	.558	-.111

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Table Eleven

Summary of Rotated Factors

Analysis	Factor No.	Tests* Which Load > .05 on Rotated Factor
Principal Components (Orthogonal)	1	5*, 6, 7
	2	2, 3
	3	14, 15, 16
	4	9, 11, 12, 13
	5	1, 10, 14
Principal Components (Oblique)	1	9, 11, 12, 13
	2	2, 3
	3	14, 15, 16
	4	8, 10
	5	5, 6, 7
Image Factor Analysis (Orthogonal)	1	5, 6, 7, 11, 13
	2	14, 15, 16
Image Factor Analysis (Oblique)	1	5, 6, 7, 11
	2	14, 15, 16

* Test Names:

1. Unobtrusive test of reading speed
2. Looking time with recall
3. Looking time without recall
4. Reading test
5. Tachistoscope test-symbols
6. Tachistoscope test-numbers
7. Tachistoscope test-letters
8. Scan test A
9. Scan test B
10. Scan test C
11. Oral reading test of high redundant words
12. Oral reading test of low redundant words
13. Counter test
14. Speed and accuracy test
15. Fixation duration for verbal material
16. Fixation duration for non-verbal material

Finally, an analysis was performed to examine the predictive power of obtrusive-threshold tests of perceptual speed on unobtrusive non-threshold tests. Tables Twelve, Thirteen and Fourteen present the outcomes for three stepwise regression analyses. In the case of both analyses which involved looking time (with and without recall, Tables Twelve and Thirteen) only 4% of the variance could be accounted for. In the analysis which involved an unobtrusive test of reading speed (Table Fourteen), 7% of the variance was accounted for by the eight steps.

In summary, scores on the various tests tended to be only slightly correlated. Ninety-six of the one hundred and twenty correlations were not sufficiently large in order to reject the null hypothesis at the .05 level. The largest correlations were produced by various forms of the same technique, i.e., tachistoscope test with numbers and tachistoscope test with letters. Given the generally low intercorrelations, the factor analysis did not yield interpretable factors across various types of tests. Further, the use of threshold scores to predict non-threshold scores resulted in multiple Rs of from .20 to .27.

The data produced by this study indicates that estimates of the processing speed of individuals tend to be inconsistent across various types of tasks. The notion of perceptual style as characterized by processing speed seems invalid given the use of the tests included in this study.

Table Twelve

Stepwise Regression Analysis with Looking Time with Recall as Dependent Variable

Step No.	Variable Introduced	Coefficient of Multiple Regression	Coefficient of Determinator
1	Oral reading with low redundant words	.10	.01
2	Speed test with counter	.13	.01
3	Tach. test with symbols	.16	.02
4	Tach. test with letters	.18	.03
5	Fixation duration	.19	.04
6	Scan test A	.20	.04
7	Tach. test with numbers	.20	.04
8	Oral reading with high redundant words	.20	.04

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Table Thirteen

Stepwise Regression Analysis with Looking Time without Recall as Dependent Variable

Step No.	Variable Introduced	Coefficient of Multiple Regression	Coefficient of Determinator
1	Oral reading with high redundant words	.10	.01
2	Tach. test with numbers	.15	.03
3	Scan test A	.18	.03
4	Tach. test with letters	.19	.04
5	Tach. test with symbols	.20	.04
6	Speed test with counter	.20	.04
7	Oral reading with low redundant words	.20	.04
8	Duration of Fixations	.20	.04

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Table Fourteen

Stepwise Regression Analysis with Unobtrusive Test of Reading Speed as Dependent Variable

Step No.	Variable Introduced	Coefficient of Multiple Regression	Coefficient of Determinator
1	Tach. test with numbers	.18	.03
2	Scan test	.21	.04
3	Speed test with counter	.23	.05
4	Tach. test with letters	.24	.06
5	Oral reading with high redundant words	.25	.06
6	Oral reading with low redundant words	.26	.06
7	Fixation durations	.27	.07
8	Tach. test with symbols	.27	.07

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APPENDIX A
TEST MANUAL

TEST 1. UNOBTRUSIVE TEST OF READING SPEED

"I'd like you to read this handout. It will explain the study." Hand subject the sheet marked "About This Study...." (Time the duration required to read the passage. If S interrupts the reading, time the interruption, record total time and interruption time. Stand behind S while he reads page which contains the following:)

ABOUT THIS STUDY . . .

You have agreed to participate in a study of visual perception. The purpose of the study is to learn more about the ways in which humans process information from the visual environment. This study is being supported by a grant from the Office of Education of the Unites States Department of Health, Education and Welfare. The investigation is under the direction of Dr. James Bosco, who is assisted by Robert Mendelsohn. Several instruments and tests will be used. It is essential that you follow the directions which will be given to you for the various tasks which you will perform as a participant in this study. You will receive five dollars as compensation for your time. You will be mailed a check in about two weeks. Now, please address the envelope on the table in front of you. This envelope will be used to mail your check.

TEST 2. TACHISTOSCOPE TEST WITH SYMBOLS

"Look into the Tscope and tell me what you see." (pause) "That is correct, there are two red dots (used to orient fixation). I'm going to show you some geometric shapes, and I want you to tell me what you see."

"I want you to press that button in front of you any time after I say 'Alright' and tell me what you saw." (Show each of the 4 shapes at 100 msec. Then show each at 5 msec). "Now, I'm going to show one

Test 2 (con't)

of the figures followed by a pattern. When you look into the box and press the button, I want you tell me ONLY what figure you saw first . . . for example, if you see a triangle and then the pattern, your answer would be 'the triangle.'" (Show all 4 at 5 msec test stimulus - 150 - msec interstimulus interval - 20 msec masking stimulus).

"Only push the button once."

"Now, there's going to be a time when the pictures will flash real fast. Even if you can't see the first picture, I want you to make a guess, this is essential to the experiment. They are all in random order. Look into the box and I'll show you." (Show two figures at 5 - 0 - 20. Get students guess). "Now, we're ready to begin the test." (Use schedule of presentations). "Once we get going I won't be telling you if you are right or wrong."

1. Make sure S has eyes completely into scope before pressing switch.

2. If S says he cannot see the figure and refuses to guess, continue for 2 more exposures. If he begins responding again, keep going to the end of the end of the test. If he does not begin responding, stop at the end of the response.

3. Keep the lights out in the room whenever a child is in the room. (Room is dim).

4. Allow a brief break at the middle of the test.

5. Break at 40 msec. Then begin testing at 50 msec.

6. Sequence for the shapes: 5 - interval - 20.

(See next page for stimuli sequence).

SYMBOLS

INTERVAL (m.sec.)	SIGN	INTERVAL	SIGN
90	star circle square triangle	40	circle triangle star star
80	star triangle circle square	30	triangle star circle square
70	star square circle triangle	20	star circle triangle square
60	square star circle triangle	10	triangle square circle star
50	square star triangle triangle	0	star square circle triangle

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TEST 3. UNOBTRUSIVE TEST OF LOOKING TIME WITH RECALL

"I am going to show you a picture. I would like you to look at it for as long as you would like. When you have examined the picture for as long as you would like, tell me you are through, and I will ask you a couple of questions about it." (Hand S the "gum card" picture and time the duration spent looking at it with S realizing he is being timed).

QUESTIONS:

1. Is there a picture of a male person on this card?
2. Is there a picture of a female on the card?
3. How many individual pictures were there on this card?
4. There was a picture of a girl. What was her name?

TEST 4. UNOBTRUSIVE TEST OF LOOKING TIME WITH OPINION

"I am going to give you two pictures and I would like you to look at them as long as you want and tell me which of the two pictures you prefer. You need not explain why you prefer the one you select." (Hand S the two pictures and time the duration spent looking at them without S realizing he is being timed).

TEST 5. TACHISTOSCOPE TEST WITH NUMBERS

1. Use same procedures as test
2. Show all number stimuli at 100 msec; then at 5 msec. without mask.
3. Show all stimuli at 5 - 60 - 20.
4. Show all stimuli at 5 - 0 - 20.
5. Give break at 24 msec; then do last 4 of 30, and continue testing.
6. See next page for stimuli sequence.

NUMBERS

INTERVAL (m.sec.)	NUMBER	INTERVAL (m.sec)	NUMBER
60	26	30	15
60	37	30	15
60	48	30	37
60	15	30	15
60	26	30	37
60	37	30	48
60	15	30	26
60	48	30	26
54	37	24	15
54	15	24	48
54	48	24	26
54	26	24	37
54	26	24	48
54	48	24	26
54	37	24	37
54	15	24	15
48	26	18	26
48	37	18	15
48	26	18	48
48	48	18	37
48	26	18	26
48	15	18	37
48	37	18	48
48	48	18	15
42	37	12	15
42	26	12	48
42	48	12	26
42	15	12	37
42	15	12	48
42	26	12	15
42	37	12	37
42	48	12	26
36	26	06	37
36	48	06	26
36	15	06	15
36	37	06	48
36	15	06	26
36	26	06	15
36	48	06	37
36	37	06	48

TEST 6. VISUAL SPEED AND ACCURACY

The administration of this test will conform to the "Examiner's Manual" for the Employee Aptitude Survey Visual Speed and Accuracy Test (Psychological Services, Inc., undated).

TEST 7. ORAL READING OF HIGH REDUNDANT LIST OF WORDS

"I am going to give you a list of words and I would like you to read them aloud. Read them correctly, but as fast as you can. First, try it with this practice list." (Begins with Meet) "Do you understand the task?" (Hand S the list which begins with green. Printed side down). "When I say 'Begin' turn the list over and start. I will be using this stop watch to time you. 'Begin.'"

PRACTICE LIST:

meet
happy
last
horse
smile
nose
never
plan
guest

(The following page contains the test list)

green	black
black	large
large	green
stand	large
green	stand
black	black
stand	stand
large	green
black	large
stand	black
large	green
green	stand
green	black
large	large
black	black
stand	large
green	green
black	stand
stand	stand
large	large
green	green
stand	black
black	large
large	stand
black	stand
green	green
large	black
stand	large
stand	green
green	black

TEST 8. ORAL READING OF LIST OF LOW REDUNDANT WORDS

"I have another list of words that I would like you to read. We will follow the same procedure. Alright?" (Hand S list which begins with little). "Begin." (The following is the test list).

little	labor
almost	white
dollar	round
letter	those
either	number
money	found
order	itself
mother	dress
might	laugh
river	large
window	office
wrong	result
great	whole
family	began
bring	follow
reach	short
force	doctor
think	garden
wrong	other
learn	rather
being	might
matter	quite
young	often
marry	return
result	happy
month	across
demand	every
answer	after
night	thing
remain	fight

TEST 9. LIST READING WITH NON-VERBAL RESPONSE

"For this test I would like you to read a list of words silently and push this counter each time you read a word that stands for a color. First try it out with this sample test." (Give S the sample list and counter). "If you make an error and hit the button twice, just continue and disregard it. Do not try to compensate by leaving out one push." (Hand the S the list which begins with green. Same list as used with the Test 7).

PRACTICE LIST:

red
blue
seldom
many
red

many
blue
seldom
red
blue

red
blue
red
seldom
many

blue
red
seldom
blue
blue

The following page contains the test list.

green	black
black	large
large	green
stand	large
green	stand
black	black
stand	stand
large	green
black	large
stand	black
large	green
green	stand
green	black
large	large
black	black
stand	large
green	green
black	stand
stand	stand
large	large
green	green
stand	black
black	large
large	stand
black	stand
green	green
large	black
stand	large
stand	green
green	black

TEST 10. TACHISTOSCOPE TEST WITH LETTERS

1. Show all stimuli at 100 msec. at 5 msec. without mask.
2. Show all stimuli at 5 - 60 - 20.
3. Show all stimuli at 5 - 0 - 20.
4. S should make a response each time.
5. Give a brief rest, as in other Tachistoscope tests

(See next page for stimuli sequence).

LETTERS

INTERVAL (m.sec.)	NUMBER	INTERVAL (m.sec.)	NUMBER
60	Z	30	H
60	X	30	Z
60	K	30	X
60	H	30	V
60	V	30	K
60	V	30	H
60	X	30	V
60	Z	30	K
60	K	30	X
60	H	30	Z
54	Z	24	H
54	V	24	K
54	H	24	V
54	K	24	X
54	X	24	Z
54	Z	24	Z
54	H	24	V
54	V	24	X
54	X	24	K
54	K	24	H
48	Z	18	X
48	V	18	K
48	Z	18	V
48	X	18	H
48	H	18	Z
48	Z	18	H
48	X	18	Z
48	K	18	X
48	H	18	V
48	V	18	K
42	Z	12	Z
42	V	12	H
42	X	12	V
42	K	12	X
42	H	12	K
42	H	12	Z
42	K	12	V
42	V	12	H
42	X	12	K
42	Z	12	X
36	Z	06	H
36	H	06	V
36	V	06	X
36	K	06	Z
36	X	06	K
36	Z	06	H
36	X	06	Z
36	K	06	V
36	V	06	Z
36	H	06	X

TEST 11. SCAN TEST ONE

"For this test I would like you to scan this sheet of groups of letters until you find a particular letter. Practice on this list by finding the letter P. Say 'Stop' when you find it. Now we are ready to begin the test. Tell me when you find the letter V."

PRACTICE LIST:

Target is P

KREEB
TGEDJ
ECAOH
TKDOE
ALEMG
XYEVY
NYESX
HECNC
ZQPHE
REISR
EEMIX
LZVZB
GREDE
GHOBU

(Test list is on the next page).

TARGET IS V

JHLKI
OTAAK
SEQEB
QQNZK
XEKPA
FGAON
DWPUK
JOQNR
CKNSG
HCDCF
XWFDL
UHEWT
NPJZW
GRKIH
LMJXH
KGJTM
HNFBO
PBQUQ
MLEJU
AWHFY
ADLUS
ALLHK
DEJZT
CDFDB
LKTOA
BFJLU
RVUAA
BQXSO
GUBLF
LOWDS
IGKYY
QCEWM
PZZAT
RPPCG
NUWDX
MWGXY
JCPYG
YBDKI
MHAYT
KWRWN
UJKAC
QEYXA
SUUGJ
WUJFI
GFTKQ
LORMX
NEDJC
EMOAD
DBKRY
BSSNY

TEST 12. SCAN TEST TWO

"This test is like the other but I would like you to find any word which is the name of a non-human animal." (Hand S list which begins with pull). (The following is the test list).

tear	pull
week	wish
fill	ball
rise	room
bank	view
step	wear
mile	year
milk	rich
turn	been
yard	felt
cost	call
warm	true
cook	deep
rock	take
sure	hear
road	half
type	suit
town	rush
goat	last
ease	flow
turn	very
gone	your
wall	ring
rest	walk
roll	step
cool	full
went	send
over	open
roof	girl
also	west

TEST 13. SCAN TEST THREE

"For this test I would like you to scan another letter list until you find a group of letters that does not have the letter S in it.

SURUO	SEJDE
GXQUS	GLSTO
HSDXI	TLTUS
RIESQ	LFETS
FLKSY	SUEPY
OWNLS	YPSAU
FPSTK	PONOS
STOMN	YPRSK
GNDSI	WESZF
IGHXS	BSTED
KGMSX	DOOSV
SFJIB	PSMOI
ZLXKC	CGQSW
OLLSI	ZSCBN
SMCYW	SQDEX
GCMSH	QAPOS
WTJTS	CDXSM
NSJFA	YUSOH
JVGSV	UWSCU
SFEZG	LNLSI
FEGMS	SHVRF
UUTDS	HRZSJ
ULSHN	GSQFE
	CMBNS
	PBOSG

TEST 14. READING SPEED

"I would like you to read the following passage. I am going to time how long it takes. After you read it I am going to ask you some questions about." (Give S passage number 1: High School-Adult College as a trial). "I would like to have you read one more passage. Again I will ask you some questions." (Give S passage 8: Adult College and record time). Ask the 4 circled questions on back of card.

TEST 15. DURATION OF FIXATION ON VERBAL MATERIALS

Follow manual for EDL Reading Eye Camera. Use passage 4 as a trial (no film) then passage 7 for test.

TEST 16. DURATION OF FIXATION ON NON-VERBAL MATERIALS

Use picture stimulus. "Now I would like you to look at the picture. Please look at the picture for as long as you like."

APPENDIX B

PROCEDURE FOR LOCATING THRESHOLDS FOR TACHISTOSCOPE TESTS

Symbols

Thresholds were located for each protocal by finding the first level where there were three or more incorrect responses. The threshold level was at the next highest level. If there were three or more correct responses in a level below the one containing the three errors, then the threshold was designated at a level above the next block of three errors.

Letters

Thresholds were located by finding the first level where there were four or more incorrect responses. The threshold was at the next highest level. If there were four or more correct responses at a level below the one containing the four errors, then the threshold was designated at the level above the next block of four errors.

Numbers

Thresholds were located by finding the first level where there were five or more incorrect responses. The threshold was at the next highest level. If there were five or more correct responses at a level below the one containing the five errors, then the threshold was designated at the level above the next block of five errors.